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EVALUATION OF THE FIRE CONTROL, ESTHETICS, AND OTHER EFFECTS OF A "GREEN BELT" FUEL BREAK DESIGNED TO PROTECT MOUNTAIN COMMUNITIES FROM WILDLIFE

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EVALUATION OF THE FIRE CONTROL, ESTHETICS, AND OTHER EFFECTS OF A "GREEN BELT" FUEL BREAK DESIGNED TO PROTECT MOUNTAIN COMMUNITIES FROM WILDFIRE

Terminal Report
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Introduction

The continuing cultural development on forest lands in the White Mountains of Arizona has posed serious problems of fire control. It is possible and probable that a wildfire on the scale of the Carrizo-Cibecue Fire of 1971 on the White Mountain Apache Reservation, the Battle Mountain Fire of 1972 on the Prescott National Forest in the Bradshaw Mountains south of Prescott, Arizona and the Sycamore Canyon Fire of 1972 on the Coconino National Forest, south of Flagstaff, Arizona could wipe out whole rural and summer home communities in the White Mountains. The same risks seem to be developing on an ever increasing scale in other forested and/or wildland areas throughout the Southwest or for that matter, throughout the forested areas of Western United States.

In this study, a "green belt" or fuel break was developed around one such developed area. The objectives of the study were to estimate and evaluate current and projected effects of this fuel break on:

1. Quantity and condition of fuels and probable wildfire behavior.
2. Changes in species composition of vegetation in the treated area.

Habitat?

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3. Changes in the esthetic quality in the treated areas.

The study site is on the White Mountain Apache Indian Reservation east of McNary, Arizona. The green belt was constructed to the south and east of a summer home and commercial development and connected with primary roads.

The green belt consisted of a fuel break 10 chains (660 ft.) wide which was surveyed by study personnel and constructed by labor furnished by the Bureau of Indian Affairs under the general direction and supervision of study personnel. Thinned woody materials (trees) were lopped and scattered. A part of the area containing two burn plots was broadcast controlled burned late in the Fall of 1974. The additional three burn plots will be burned in the Fall of 1975 providing the funds are available for supervision and data collection. Minimum basal areas of 50-60 square feet were maintained on the treated area.

Before the fuel break was constructed, five(5) sets of paired sample plots 8.71' by 100' (total of ten 1/50 acre plots) were established, one plot of each pair was located in the projected green belt area and one plot was located in the adjoining untreated forest. These plot pairs were selected subjectively for similatity between pairs in: vegetational cover, slope, aspect, soils, and geographic features. Initial data was collected on: plant species present and density (this would include surface vegetation and tree dominants), existing surface fuels, and evidence of past fire history. Size (d.b.h.) and heights were taken for all tree size vegetation. An extra plot was located in the area to be burned after the plots were reviewed in the field. Thus one control plot has two counterparts in the area to be control burned.

All plot data were recorded in permanent record books, a single bound record book has been set up and maintained for each plot. All tree locations were plotted on maps and trees removed in the thinning treatments were circled on the maps.

Fuel Measurements

Litter and Large Ground Fuels. Fuel measurements were made on all plots. These measurements consisted of the following:

1. Total depth of all organic material
2. Depth of compacted fine and partially decomposed litter (01 layer)
3. Depth of loosely arranged fine and coarse surface litter (02 layer)
4. Presence and prevalence of large dry surface fuels (2" and larger).

To develop guides for quantitatively estimating the fuels present on each plot, all of the organic material was removed by layers from a minimum of 2 subplots located in the vicinity of the perimeter of the permanent plots and weighed. This data was added to the overall data base developed in the larger fire study being made on the Mogollon Rim and North of McNary, Arizona. The data so collected was then used as a basis for quantitatively determining fuel changes due to treatments.

Total dry weight of litter and decomposition layers will be determined by plot and per acre as follows:

Litter depth measurements, taken at random (15 in each plot, using computer generated random position output), were used as indicators of the area of soil covered by organic matter. In addition, they will be used as indicators of fire influence on the organic matter on the soil surface under the different conditions of fire history. Measurements have been or will be made in all plots on each side of the fire line, which

was made to stop the controlled fire and which will serve as the treatment boundary between the controlled burn and no-treatment areas. Litter measurements consisted of the following:

1. Depth of loosely arranged fine and coarse surface litter (O1 layer).
2. Depth of compacted fine and partially decomposed litter (O2 layer).
3. Total depth of litter.

To develop guidelines for quantitatively estimating the fuels present on each plot, all of the organic material was removed and weighed by layers from subplots in the vicinity of unburned plots located throughout the area in which the fire studies are being conducted (total of 241 subsamples). This data was used to determine the total dry weights of the O1 and O2 layers in the following manner:

1. Two 1 ft. by 1 ft. sub-plots were located randomly in the vicinity of each plot of each plot pair in 3 undisturbed areas.
2. Three O1 and three O2 layer depths were measured for each subplot and the mean determined.
3. The O1 and O2 layers were collected from each subplot and placed in separate paper bags.
4. The bags of litter and organic material were then oven dried for 24 hours at 120° F. and weighed.
5. The means were determined for each layer per cm of depth to obtain the fuel weight constants used to estimate the weights of fuels present in each plot.

The weights of the O1 and O2 layers were determined for all greenbelt plots (control and treatment plots) as follows:

1. Litter depths and decomposition layer depths were measured at

15 random points in undisturbed areas in each plot.

2. Dry weights of litter and decomposed layers were calculated for each plot by multiplying the mean litter depth of the plot by the dry weight constants determined from the litter weight studies.

Green Fuels. The surface vegetation will not be included in the fuel measurements, however, records were kept of surface vegetation species and densities before treatments. After treatment records will be collected when available and/or possible.

The main objective of the green belt was to reduce the quantity and interrupt the continuity of the high fuels by extended spacing of tree crowns and to reduce the quantity of the surface fuels through controlled burning. These reductions and interruptions in fuels should lessen fire intensity in such areas to the point: that crown fires will drop to the ground and become ground fires, and a focal area for the attack and control of ground fires threatening developed areas.

Vegetation

Surface Vegetation. Records were made describing understory vegetation including species and percent cover. Species abundance and percent cover were estimated by running 10 one meter wide strips across the width of the plot at randomly located points along one side.

Woody Tree Vegetation. Records mainly pertain to the dominant ponderosa pine vegetation. However, all trees were measured and included in the records and on the maps. Gambel oak (Quercus gambelii) would be the principle secondary species and it may exhibit an interesting long term response to controlled burning treatments that could influence game habitat

and esthetics. The data to be collected on tree vegetation consists of the following:

1. All of the trees in each plot over 2" DBH were located and recorded on plot maps.
2. All of the trees on each plot were classified into two inch diameter classes and average heights were determined for each diameter class. Evidence of prior damage by fire, disease, unusual deviations in form or growth, etc were noted by individual trees.
3. After the advent of fire in the controlled burning treatment, the degree of damage will be assessed by tree diameter classes on trees 2" DBH and over as follows: (Due to weather unfavorable to burning this phase of the study was not completed).
   a. Crown damage. If immediate damage assessments are made, then assessments (at least 3 months later) must also be made of those trees having seriously damaged crowns showing green foliage. Crown damage will be assessed under the following categories:
      (1) All foliage consumed (tree dead)
      (2) All foliage brown and tree considered to be dead
      (3) Less than 1/4 of the foliage green and alive (tree has little chance of survival).
      (4) More than 1/4 but less than 1/2 of the foliage green and alive (tree weakened but has a good chance of survival).
      (5) More than 59% but less than 75% of the foliage green

and alive (tree has excellent chance of survival)

(6) Over 75% of the foliage green and alive (crown essentially undamaged and tree will usually survive)

b. Trunk damage. Trunk damage will be assessed under the following categories:

(1) Trunk severely scorched all around and/or bark mostly burned away.

(a) Confined to first 2 feet of the trunk.

(b) Covering up to first 5 feet of the trunk.

(c) Covering over 5 feet of the trunk.

(2) Trunk moderately scorched, cat faces formed in the bark but generally bark not completely burned.

(a) Confined to first 2 feet.

(b) Confined to first 5 feet.

(c) Five feet and above.

(3) Trunk lightly scorched or blackened, burned out new cat faces usually absent, bark structure generally well defined and easily visible.

(a) Confined to first 2 feet.

(b) Confined to first 5 feet.

(c) Five feet and above.

Photographs were taken from photographic points of every plot. These photographs were made and kept as before and after treatment visual records of the vegetation and vegetation composition existing on each plot. Also, they can be utilized to illustrate changes in vegetation and to some extent, esthetic changes occurring in the green belt resulting

from logging and controlled burning.

In addition to the above photographs, other photographs were made at random locations (a minimum of 20) of before and after treatment results to be used as additonal records for assessing esthetic changes in the vegetational cover as the result of creating the green belt fuel breaks.

Special items of interest in relation to vegetation change, wildlife use, esthetic change, etc., may also be included in the photgraphic record.

ANALYSES

Snedecor (1956) states that environmental variation often calls for pairing and his basic criteria for pairing successfully was whether or not twos could be found that differ between themselves less than from other twos. He also stated that it must be known that the individuals of a pair will behave alike (aside from random variations) if treated alike. The work of Weaver (1951), Kallander (1960), and Biswell (1956), and others indicates that similar results can be expected from controlled burning in similar fire environments. Thus, two plots next to each other are more likely to have similar fire environments and will respond more nearly alike than two at a distance (Snedecor, 1956), especially when subjectively selected for similarity in regards to vegetation, fuels, physiographic detail, etc. Snedecor (1956) also stated that economy is attained by pairing similar individuals and cited one example wherein 40 random pairs would have been required to reach the same precision obtained with 8 pairs.

The paired plot design utilized in this study should adequately sample the forest type in question, since most combinations of aspect, fuel quantity, size of dominant vegetation, etc., will be included in the pairs set up. Also, the plot treatments will have been randomized insofar as practical considerations of building the green belt will allow. The green belt containing the plots to be treated will be located by a forester whose only objective is to develop the best (most practical and secure) green belt firebreak around the area to be protected, and at the same time, maintain the integrity of the established plots.

The statistical analyses to be used on these plots will consist of the following:

1. After the initial data is collected, the mean, variance, standard deviation, standard error of the mean and confidence intervals at the 0.05 level were computed. These will be used to determine whether or not the sub-sample numbers are adequate. If more samples are needed, the above analyses will be again repeated.
2. Two tailed F tests for homogeneity will be used to check the assumption that paired plots are in fact similar.
3. After controlled burning, treatment differences "between burned and unburned plot pairs" will utilize the paired "t" test.
4. If studies over time can evolve from this study, relationships between time and fuel accumulations and time and vegetation changes (plant succession) will utilize Linear Regression and curves will be ultimately developed to indicate fire damage potential and need for controlled burning.

Examples of the differences that can be "expected" to occur within and between the individual plots of plot pairs as the result of controlled burning and thinning treatments in a ponderosa pine vegetation type are:

1. Changes in fuel quantity and/or depth.
2. Changes in numbers of density of surface vegetation.
3. Changes in number or kinds of species.
4. Changes in growth rates of the dominant species, ponderosa pine.
5. Differences in damage to individual dominant plants.
6. Differences in surface organic layers of soil.
7. Differences in soil fertility.

Most of the differences found in this study should be obvious and the statistics will mainly serve as a means of organizing and quantitatively relating and presenting them.

RESULTS

General

This study has not been completed in its entirety as first conceived and proposed. The first year of the study the green belt plots were located and all pre-treatment data were taken and the greenbelt-thinning treatments were completed. However, due to a change in tribal policy, the projected pulpwooding operation was not followed. Thus all of the larger woody material was lopped and scattered, and it did not dry out enough for the controlled burning treatment to be undertaken the first fall after treatment. (Fall of 1973). This last fall (Fall 1974) good controlled burning conditions did not materialize, although one section of the greenbelt, including two samples plots, was burned. This

area was directly south of a large homesite development and it was felt that the fuels accumulated as the result of the greenbelt treatments should not be carried through another fire season. The part of the green belt containing the three other plots to be controlled burned was held over until next fall, at which time it will be burned. If conditions are good for a broadcast controlled burn this will be done, otherwise all of the large materials will be further lopped and piled and burned under the best conditions possible.

This coming spring, it is hoped that the two plots already controlled burned can be analyzed, and that the following spring the remaining three plots can be analyzed and comparisons made on differences occurring between years and between treatments.

Surface Fuels

Litter. Table 1 shows the depths of the O1 and O2 litter layers measured before any treatments were made. Each plot pair was subjectively selected for similatities, between the individual plots comprising each pair, in aspect, slope, elevation, the dominant vegetation (trees), and surface vegetation. The individual plots of each pair were always located in close proximity to each other. Despite the care used in locating the individual plots of each plot pair it can be seen that very significant differences existed between the means of the litter layers of several plot pairs. The litter weights in gms/square meter and volume in cubic meters were from three to several times deeper than the O2 litter layers and O1 litter layer volumes were concurrently higher than O2 litter layer volumes. However, because of higher densities of the

compacted organic matter in the 02 litter layers, the differences in weight between the 01 and 02 layers were not nearly so great and in some plots the 02 layer weighed more than the 01 layer (compare mean weight in plots 1A-01 and 1A-02, $3A_2$-01 and $3A_2$-02, 4A-01 and 4A-02, and 5A-01 and 5A-02). The greater depth and lower density of the 01 litter layer throughout the plots indicate that these fuels would be the first to ignite and probably would burn the fastest with the least damage to the residual vegetation under conditions favorable for controlled burning.

The Foote Canyon study indicated that removal of this 01 litter layer through controlled burning results in much greater protection against serious damage by wildfire. The denser, heavier (per unit of depth) 02 layer apparently is more fire resistant and by itself will not carry a fire, even under high fire danger conditions, hot enough to seriously damage residual woody (tree) vegetation (See Foote Canyon report).

Large Fuels. Table 2 shows the weights and volumes of large fuels found on the greenbelt plots before treatment. A mean value was determined for the eleven plots of 260 gms/meter^2 or 5.11 cubic meters/hectare (equals 74.161 cubic ft/acre or 1.80 ton/acre) of large fuels. No statistical analyses were made of these data. The data from this study will be included along with the data from our large fire studies on controlled burning involving many more plots.

Vegetation

Ground Cover. TAbles 3 and 4 show the species present and recorded in the quadrat and line intercept studies made on the greenbelt plots.

Table 3 shows species densities recorded in the quadrat studies. Some species were present in significantly or highly significantly different numbers on the paired plots (Ex. Achillea lanulosa density differences between Plots 2A and 2B, highly significant; Plots $3A_1$ and 3B, highly significant. Muhlenbergia rigens density differences between: Plots 3A, $3A_2$ and 3B significant.) However, considering the number of species present and the few instances of significant differences in species densities between plots it can be said, that the surface vegetation of each plot pair was very similar between plots.

Table 4 shows the composition of the ground cover by species as determined by the line intercept method (Canfield 1941 and 1942). The percent of ground surface (bare ground) devoid of surface plants is also shown. Here again, it can be said, that the significant differences occurring between the individual plots of each plot pair were very few. A few significant differences occured in species cover between plots and one plot pair showed a significant difference between plots in the percent of bare ground. The individual plots of each plot pair were very similar in the species making up the ground cover, and with one exception, total ground cover.

Dominant tree vegetation (Ponderosa Pine). Table 5 shows the number of ponderosa pine trees and the basal area of the trees located on the Hondah greenbelt plots before and after thinning. The mean basal area of the six thinned plots located within the greenbelt area was 3.33 sq ft (166.5 sq ft/acre) and of this 2.33 sq ft of basal area was removed in the thinning operation, leaving a mean 1.41 sq ft basal area/plot or 70.5 sq ft basal area/acre. The mean number of trees before thinning

was 51.21/plot (2560 trees/acre) and the mean number of trees after thinning was 5.2 trees/plot (260 trees/acre).

Table 6 shows the distribution of D.B.H. classes occurring in the greenbelt plots before and after thinning. The trees to be left were individually selected and marked. Criteria used in selecting trees to be left had their basis in Keen's classification system. A good healthy crown was a primary criteria, however, crown spacing and evidence of pathological or mechanical damage or deformity were also important considerations.

The initial objective of this thinning treatment was to reduce the residual stand on the greenbelt to 50 sq ft basal area. However, as the thinning progressed, it became apparent that a reduction to a 50 sq ft basal area would open the stand up too much from an esthetic viewpoint and would greatly enhance the damage potential from wind and snow to the residual stand. In this situation, reduction of the basal area to 70.5 sq ft/acre seemed to give adequate crown spacing and site protection. Probably this area will require a good commercial thinning within the next ten years to reopen the canopy and maintain the fire protection potential of the greenbelt. This would be an important aspect for continued study.

Table 1. Mean Depths, Weights, Volumes and Statistical Differences Between Means of the O1 and O2 Litter Layers on the Hondah Greenbelt Plots Before Treatment

Plot-Litter Layer	Litter Depth Means (mm)	Litter Weights Based on Means (gm/m^2)	Litter Volumns Based on Means (m^3)	Statistical Differences Between Means
1A-01	12.014	970.13	0.96	**
1B-01	18.065	1365.70	1.44	
1A-02	4.959	1081.10	0.40	ns
1B-02	3.442	751.36	0.27	
2A-01	12.432	1003.99	1.00	**
2B-01	19.813	1603.17	1.59	
2A-02	3.000	655.00	0.24	ns
2B-02	3.293	718.87	0.26	
$3A_1$-01	11.333	914.97	0.91	**
3B-01	18.333	1476.64	1.47	
$3A_1$-02	1.800	393.20	0.14	**
3B-02	3.347	730.65	0.27	
$3A_2$-01	14.108	1138.64	1.13	**
3B-01	18.333	1476.64	1.47	
$3A_2$-02	5.514	1203.08	0.44	**
3B-02	3.347	730.65	0.27	
4A-01	17.413	1403.04	1.37	**
4B-01	7.587	612.55	0.61	
4A-02	6.413	1400.86	0.50	**
4B-02	2.240	489.32	0.18	
5A-01	13.987	1128.96	1.10	ns
5B-01	15.657	1262.56	1.25	
5A-02	6.160	1345.20	0.49	ns
5B-02	4.387	956.98	0.35	

Litter Layer	Depth mm	Litter Wt. (gm/m^2)	Litter Volumn (m^3)
O1 Total	179.075	14,356.99	14.3
Mean	14.923	1,196.42	1.9
O2 Total	47.902	10,456.27	3.81
Mean	3.992	871.36	0.32

** Significant at the $\alpha = 0.01$ level (highly significant).
ns Not significant.

Table 2. Weights and Volumes of Large Fuels[1] Measured on the Hondah Greenbelt Plots Before Treatment.

Plot	Large Fuel Weights[2] (mm/m^2)	(Ton/acre)	Large Fuel Volumns (m^3/Plot)	ft^3/acre	(m^3/ha)
1A	328.0	1.461	0.052	91.818	6.42
1B	328.0	1.686	0.060	105.944	7.41
2A	189.0	0.843	0.030	52.972	3.71
2B	63.0	0.281	0.010	17.657	1.24
$3A_1$	189.0	0.843	0.030	52.972	3.71
$3A_2$	63.0	0.281	0.010	17.657	1.24
3B	63.0	0.281	0.010	17.657	1.24
4A	819.0	3.653	0.130	229.545	16.06
4B	126.0	0.562	0.020	35.315	2.47
5A	630.0	2.810	0.100	176.573	12.36
5B	63.0	0.281	0.010	17.657	1.24
Total	2861.0	12.982	0.462	815.767	57.10
Mean	260.0	1.180	0.042	74.161	5.19

(1) Dead and down woody material 2' or more in diameter.
(2) Based on a specific gravity of 0.51 (Beaufait and Hardy, 1974).

Table 3. Species Present and Species Density in Plants per Quadrat[1] on the Greenbelt Study Plots Before Treatment.

Species Present	Plots										
	1A	1B	2A	2B	$3A_1$	$3A_2$	3B	4A	4B	5A	5B
Achillea lanulosa	29.40	17.50	10.90**	3.00	0.40**	13.20	6.00	A[2]	A[2]	2.70	3.40
Antennaria aprica	A[2]	A[2]	A[2]	A[2]	A[2]	12.20	A[2]	A[2]	A[2]	A[2]	A[2]
Calliandra humilus	A	A	A	A	A	A	A	A	1.30	A	A
Castilleja austromontania	A	A	0.30	0.10	A	A	0.40	A	A	A	A
Ceonothus fendleri	A	A	A	A	A	A	A	A	A	0.30	A
Cirsium wheeleri	5.00	4.60	6.00	4.20	1.60**	9.20	11.20	1.90	0.90	0.60	0.30
U.D.C.[3] #1	1.50	1.30	0.80	A	0.20	A	1.10	0.50	0.70	A	2.70
U.D.C.[3] #2	A	A	A	A	A	A	A	0.10	0.50	A	A
Erigeron divergens	11.70	1.50	A	2.40	A	3.00	A	A	A	A	A
Erigeron flagellaris	1.20	0.60	0.30	1.60	A	1.50	A	A	A	0.70	A
Geranium caespitosum	0.40	A	0.10	A	A	0.70	0.60	1.00	0.60	0.20	0.40
Houstonia wrightii	0.10	0.20	A	A	0.40	0.30	0.60	A	A	A	A
Lotus wrightii	A	0.10	A	A	0.10	A	A	0.40	A	0.10	A
Moss	A	A	0.30	0.10	0.10	1.40	0.10	A	A	A	0.10
Muhlenbergia rigens	1.60	3.20	2.90	2.30	0.90*	0.60*	3.40	0.70	0.30	0.40	1.20
Muhlenbergia virescens	A	A	A	A	A	A	A	2.30	1.80	0.50	0.20
Parmelia sp. (lichen)	A	1.50	3.50	1.30	6.40**	2.70*	0.20	0.40**	5.40	1.20	0.60
Pinus ponderosa[4]	0.60	0.30	2.80	2.00	2.30	1.90	2.60	1.00	2.50	1.40	0.70

Table 3 (con't).

Species Present	Plots 1A	1B	2A	2B	$3A_1$	$3A_2$	3B	4A	4B	5A	5B
Poa fendleriana	13.80	10.80	4.30	5.10	3.70	A	2.10	1.90	A	0.70**	6.40
Potentilla sp.	A	0.50	A	A	A	A	A	A	A	A	0.20
Pseudocymopteris montanis	0.40*	3.90	1.50	3.20	0.20*	4.20	3.70	1.30	A	1.00**	0.10
Quercus gambelli	3.80	2.60	1.70	2.40	0.70	0.10	0.10	0.30	0.10	0.20	0.90
Senecio neomexicana	3.40	2.20	5.50**	0.40	0.70	4.70*	0.60	1.80	A	0.80	2.60
Senecio wootonii	A	A	A	A	A	A	A	A	A	A	0.40
Sitanion hystrix	10.20	5.40	4.90	6.40	3.30*	5.00	7.20	3.80*	1.00	5.90	3.70
Solidago missouriensis	A	A	A	A	2.20	A	0.40	A	A	0.50	A
Solidago sparsiflora	A	A	0.30	0.60	A	A	A	A	A	A	A
Thalictrum fendleri	A	A	A	A	A	A	A	3.50	A	A	A
Vicia americana	1.10	0.50	1.10	A	0.40	A	A	1.70	2.80	0.80	0.20
Bare ground											

1 Quadrat means are based on the total number of plants counted in 10 quadrats in each plot (Quadrat r meanx30.48 = number of plants/1/50 acre.)
2 A = Absent
3 Unidentified composite
4 All trees
* = α significant at the 5% level
** = α highly significant at the 1% level

Table 4. Composition in Percent of the Vegetative Groundcover and Bare Ground in the Greenbelt Study Plots Before Treatment.

Species Present	Plots										
	1A	1B	2A	2B	$3A_1$	$3A_2$	3B	4A	4B	5A	5B
Achillea lanulosa	5.30*	1.80	2.20	1.80	0.20	0.20	1.20	A[1]	A[1]	0.30	2.10
Antennaria aprica	A	A	A	A	A	0.50	A	A	A	A	A
Calliandra humilus	A	A	A	A	A	A	A	A	1.60	A	A
Castilleja austromontania	A	A	A	A A	A	A	0.20	A	A	A	A
Ceomothus fendleri	A	A	A	A	A	A	A	A	A	A	A
Cirsium wheeleri	1.00	1.20	1.70	2.10	0.40*	0.70	3.20	3.70	0.60	0.10	A
U.D.C.[2] #1	1.20	0.10	0.10	A	A	A	0.30	A	0.20	A	A
U.D.C. #2	A	A	A	A	A	A	A	A	0.70	A	A
Erigeron divergens	0.60	0.40	A	0.70	A	0.10	A	A	A	A	A
Erigeron flagellaris	1.80	0.20	0.20	A	A	A	A	A	A	0.20	A
Geranium caespitosum	0.20	A	1.10	A	A	A	A	1.00	0.10	2.10	A
Houstonia wrightii	A	A	A	A	A	A	A	A	A	A	A
Lotus wrightii	A	A	A	A	A	A	A	A	A	A	A
Moss	A	A	A	0.20	A	A	A	A	A	A	A
Muhlenbergia rigens	7.50*	1.70	1.20	1.50	1.70	0.80	0.70	1.30	A	A	A
Muhlenbergia virescens	A	A	A	A	A	1.10	A	2.20	0.50	A	0.90
Parmelia sp. (lichen)	A	A	0.70	A	2.40*	0.70	0.20	A	3.00	0.20	A
Pinus ponderosa[3]	A	0.20	A	A	A	A	A	1.30	A	A	A

Table 4 (con't).

Species Present	Plots										
	1A	1B	2A	2B	3A[1]	3A[2]	3B	4A	4B	5A	5B
Poa fendleriana	2.70	5.30	6.70*	0.70	1.40	0.60	0.30	3.00	A	0.90	2.70
Potentilla sp.	A	A	A	A	A	A	A	A	A	A	A
Psuedocymopteris montanis	0.70*	3.30	1.80	2.20	0.50	0.40	1.20	2.20	A	1.80	0.10
Quercus gambelii	180	0.70	A	10.80	A	2.00	0.20	170	0.50	5.50	A
Senecio neomexicana	1.20	0.20	1.20	A	0.40	A	0.40	0.50	0.20	A	0.80
Senecio wootonii	A	A	A	A	A	A	A	A	A	A	1.30
Sitanion hystrix	1.00	2.60	1.70	1.90	1.70	0.50	1.40	1.10	1.10	2.40	1.20
Solidago missouriensis	A	A	A	A	1.20	0.10	A	A	A	0.20	A
Solidago sparsiflora	A	A	A	A	A	A	A	A	A	A	A
Thalictrum fendleri	A	A	A	A	A	A	A	1.50	A	0.20	A
Vicia americana	A	A	0.10	A	A	A	A	1.70	1.20	0.40	0.10
Bare Ground	75.00	83.10	81.10	77.90	90.00	92.20	90.50	78.80*	89.40	85.70	90.70

1 A = Absent
2 Unidentified composite
3 Only trees under 3 ft high
* = α significant at the 5% level

Table 5. Number and Basal Area of Ponderosa Pine Trees on the Greenbelt Plots Before and After Thinning Treatments[1].

Plot No.	Before Treatment		After Treatment		BA Remove
	Trees/Plot	BA/ft^2	Trees/Plot	BA/ft^2	
1A	23	2.61	7	1.20	1.41
1B	12	1.64	-	-	-
2A	71	3.79	4	1.02	2.77
2B	97	4.07	-	-	-
3A$_1$[2]	66	5.11	6	1.96	3.15
3A$_2$[2]	61	3.65	4	1.02	2.63
3B	84	4.16	-	-	-
4A	49	3.84	6	1.48	2.36
4B					
4B	48	3.54	-	-	-
5A	33	3.44	4	1.77	1.67
5B	19	4.51	-	-	-
Totals	564	40.36	31	8.45	13.99
Mean	51.2	3.33[3]	5.2	1.41[4]	2.33

1 Only the "A" plots were in the thinned area.
2 A second 3A plot was located and measured because of site differences.
3 Equals mean of 166.50 BA/ft^2 per acre before treatment.
4 Equals mean of 70.50 BA/ft^2 per acre after treatment.

Table 6. Distribution of D.B.H. Classes in Ponderosa Pine on the Greenbelt Plots Before and After Thinning Treatments[1].

Plot	<2	2-<4	4-<6	6-<8	8-<10	10-<12	12-<14	14-<16	16-<18	18-<20
1A	8 : 0[1]	2 : 0	9 : 5	3 : 2	1 : 0	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0
1B	3	3	2	1	0	0	1	0	0	0
2A	37 : 0	23 : 1	5 : 0	5 : 2	1 : 1	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0
2B	60	22	12	2	1	0	0	0	0	0
$3A_1$	30 : 0	18 : 1	13 : 3	4 : 1	0 : 0	0 : 0	0 : 0	1 : 1	0 : 0	0 : 0
$3A_2$	35 : 0	12 : 1	8 : 0	5 : 2	1 : 1	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0
3B	44	22	17	2	0	0	0	0	0	0
4A	13 : 0	22 : 0	8 : 1	6 : 5	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0
4B	14	21	8	5	0	0	0	0	0	0
5A	7 : 0	8 : 0	13 : 1	3 : 1	1 : 1	0 : 0	1 : 1	0 : 0	0 : 0	0 : 0
5B	1	2	7	3	6	0	0	0	0	0

1 Only the "A" plots were in the thinned area and show a "Before" and "After" distribution.

Esthetic Quality Changes in a Treated Greenbelt

Measurement of the changes in the esthetic quality of the greenbelt area after the initial thinning treatment has been completed and the procedures followed are given in detail in addition to the results. Thus subsequent evaluations may follow these same procedures to test changes in esthetic quality from the controlled burning treatment and changes in quality due to the passage of time which may result from increases in surface vegetation (density and species enrichment), tree growth, wildlife use etc. All later studies could then be related back to this original evaluation.

Hypothesis — The public feels that an untreated forest area is esthetically more pleasing than a treated "greenbelt" fuel break.

To prove this assumption a method had to be found that would yield statistically valid data on public reaction to the two sites (treated and untreated). A first approximation to this criterion resulted with the adoption of Boster and Daniel's (1972) method of measuring public response to vegetative management based on the Theory of Signal Detection (Green, D.M. and J.A. Swetts, 1966). It is a comprehensive, tested approach that yields cardinal measures for a Perceived Esthetic Value which is directly relevant to the hypothesis stated above.

This method ascribed to an observer's esthetic judgement of a landscape two components: 1) the observer's perception of the area, and 2) the observer's personal judgement criteria. Observer's perception of different areas cannot be compared on their face value to give a valid index of the degree of their like or dislike of forest treatments. People's judgemental criteria as well as their response bias act upon

the values they assign to their perception of the landscape. The theory of Signal Detection (TSD) supplies a method capable of overcoming the bias to yield unbiased perceptual indices. It does this by deriving a set of probabilities by mathematical transformations from cumulative frequency data. Condition 1 (treated) was plotted against itself to give a positive diagonal. A curve (for Condition 2) was developed by plotting the cumulative probability for each judgement category Condition 2 against the associated probabilities of Condition 1. The more Condition 2 is favored relative to Condition 1, the higher the Condition 2 curve will be above the positive diagonal. Conversely, the less Condition 2 is favored relative to Condition 1, the lower the curve will be below the diagonal. The distance between the curve and the diagonal is an actual measure of like or dislike between areas (Perceived Esthetic Value). This is measured by using the mean distance (d_m) of the obtained points on the curve, after standardizaiton, from the diagonal. The higher the numerical d_m value, the greater the Perceived Esthetic Value. This value is un-biased because it was computed across all observer judgement criteria levels.

Procedure. The procedures used in gathering data for this report are described so that future data can be collected in the same way in future years as part of a continuing re-evaluation of the esthetic qualities of the "green belt" fuel break treatment.

The sites (Fig. 1 Map) were located on the White Mountain Apache Indian Reservation west of McNary, Arizona. The fire break area consisted of a fuel break ten chains (660 ft.) wide extending in a belt around summer home sites. A mean basal area of 166.5 sq ft/acre on the

untreated forest was reduced to a mean basal area of 70.5 sq ft/acre to constitute the "green belt" fuel break. This was done by thinning trees and lopping slash as described earlier. The sites were visited on a sunny, clear day in early May of 1974 (a very dry month). Thirty pictures of the fuel break and thirty of the untreated forest adjacent to the break were taken on daylight color film between 10 and 4 o'clock to minimize excessive shadows. These pictures were taken in a random manner as follows. Since the fuel break was narrow, walking was was down one side of the fire break with pictures taken at eye-level into the thinning at random compass headings according to a random number table with a fifty foot pacing between pictures. A similar procedure was followed walking back on the untreated west side to obtain a second series of pictures. After the film was processed and made into 2x2 color slides poorly exposed slides or slides that showed telephone poles, roads, etc. were discarded. From the remaining slides twenty of each area were randomly drawn, mixed and loaded into a slide projection tray. The slides were then shown to several varied classes of students, not assiciated with forest management, at Pima Community College and the University of Arizona. The responses of college students to various forest treatments has been correlated to be basically similar to that of the public (Boster, R.S. and T.C. Daniel, 1974) (the public being a collection of various special interest groups such as church groups, clubs, etc.). Each class was read the rating scale instructions, issued answer sheets and then shown each slide for approximately seven seconds. (Table 7 shows a sample rating.) All questions, except those pertaining to the rating procedure, were unanswered until after the slides were completely

shown. The total number of answer sheets was reduced by discarding all incomplete sheets as well as any goofs such as sheets using numbers not on the rating scale. From the remaining sheets, fifty were drawn to be used in the actual computation to determine if there were any patterns in observer response. The data was then organized for computer analyses and analyzed.

Conclusion

The analysis of data from this experiment proved the hypothesis that an untreated forest area was more esthetically pleasing than the treated "greenbelt" fuel break. The data yielded a mean rating for Condition 1 (treated fuel break) of 4.77 and a mean rating for Condition 2 (untreated) of 5.96 from the rating scale. The difference between the mean ratings of Condition 1 and Condition 2 was statistacally significant at $P<.025$ levels. The untreated area was judged to be more esthetically pleasing than the treated area. An actual Perceived Esthetic Value was derived from the statistically significant ratings of these two areas of .11 for Condition 1 and .64 for Condition 2. These are numerical expressions of the slide rating data showing again that Condition 2 was liked more than Condition 1. The values are in a form that can be compared with future esthetic measurements of these areas to see if there are any changes in esthetic qualities during a period of years.

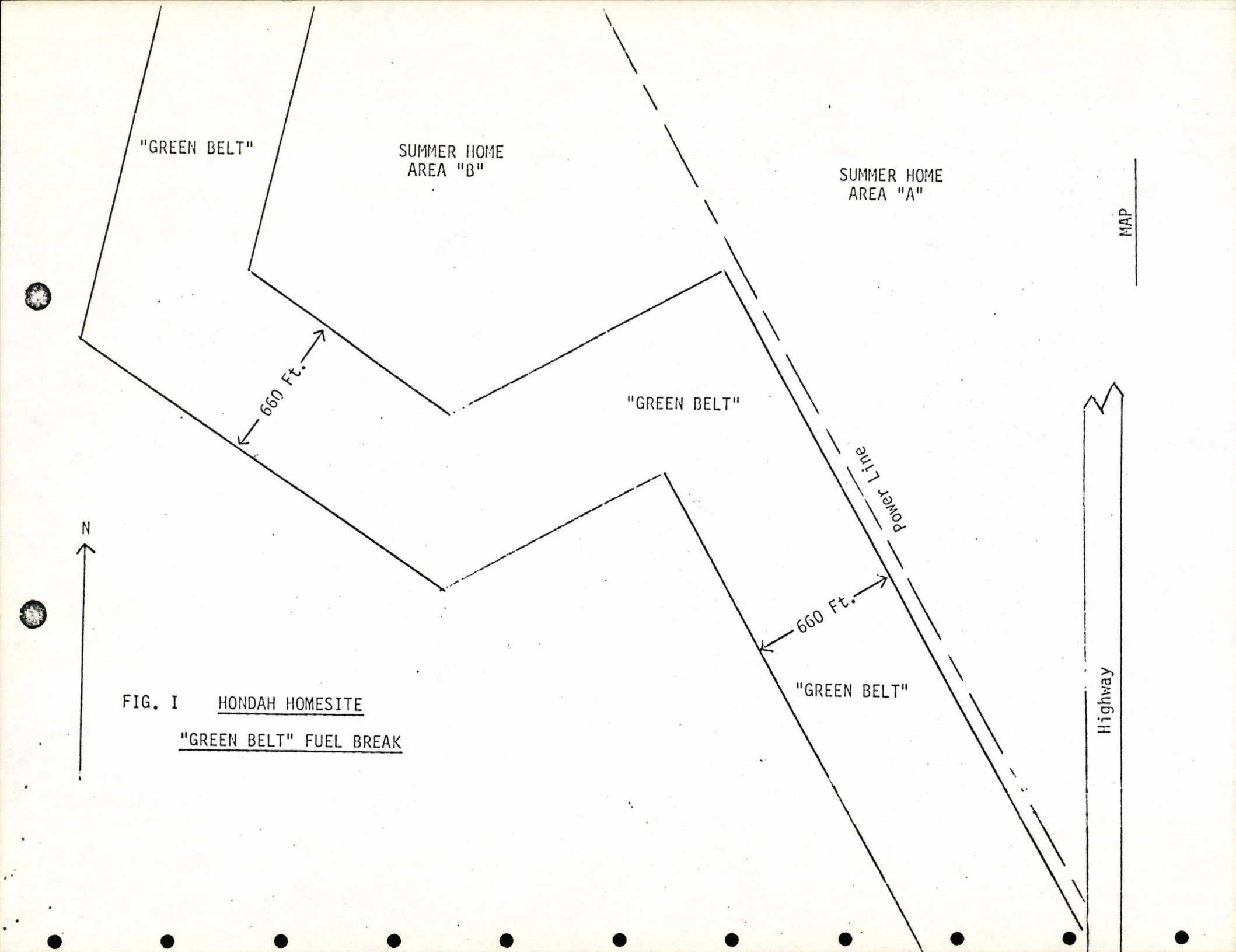

FIG. I HONDAH HOMESITE

"GREEN BELT" FUEL BREAK

Table 7. A Sample Rating Response Sheet With the Scenic Quality Rating Scale.

SCENIC QUALITY			
LOW 0 1 2 3 4 5 6 7 8 9 HIGH			
1.	4	21.	4
2.	4	22.	4
3.	4	23.	4
4.	4	24.	4
5.	4	25.	5
6.	4	26.	5
7.	4	27.	4
8.	2	28.	5
9.	4	29.	5
10.	4	30.	4
11.	4	31.	4
12.	6	32.	5
13.	3	33.	4
14.	4	34.	4
15.	3	35.	6
16.	3	36.	4
17.	7	37.	4
18.	3	38.	5
19.	8	39.	5
20.	3	40.	5

DISCUSSION

Various studies indicate that reducing ground fuels and opening up forest stands in the ponderosa pine type tends to reduce the catastrophic nature of wildfires (Truesdell, 1969; Kallander, 1963 and 1969; and Knorr, 1963). In some of these studies, it is indicated that under many conditions a crown fire cannot be sustained without heavy accumulations of surface ground fuels. Baldwin, Kallander, and Komareck[1] have cited many instances wherein they observed that a crowning fire had dropped to the ground when it reached an area that had previously been controlled burned. Thus, a concept of creating a fuel break by greatly reducing fuel quantities and continuity in both ground fuels and tree crowns should be valid. Especially if this fuel break is periodically renewed by controlled burning to keep the ground fuels from accumulating to a hazardous degree.

Thus far in the study the fuel quantities have been measured on the study plots and these measurements indicate a significant variability exists between the individual plots of the plot pairs. Thus when we evaluate the effect of the various treatments on fuel changes it will be necessary to compare the before and after data taken on the same plot.

However, when plot comparisons were made between the individual plots of the plot pairs utilizing their vegetational characteristcs they were found to be very similar in regards to species present, species density, ground cover, and dominant species (ponderosa pine) cover. The tree canopy was completely closed prior to treatment. After treatment, distances between tree canopies varied from approximately 5 to 20 ft with a mean of about 12 ft.

The main value of the untreated control plots will be for making

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1 Personal communications

continuing comparison measurements between treated and untreated areas on the changes occurring in both surface and dominant (tree) vegetations. Comparisons should also be made between treated and untreated areas on tree growth differences occuring in stems and crowns, and seed or cone production. The vegetational changes due to treatment such as: 1) The immediate esthetic effect of thinning (already completed), 2) Changes in esthetic value due to fire and/or the invasion of new species, increases in density of species present, and growth over time of residual trees, and 3) Increased use by people and animals.

The first esthetic evaluation given in this paper on a treated (thinned) greenbelt area and a contiguous untreated (unthinned) area indicated the untreated area had the highest esthetic appeal to the viewers sampled. This initial study should form a good base for subsequent studies of the same areas which would evaluate the esthetic impact of thinning and controlled burning on vegetation species, density, and growth changes occurring over time as the result of these treatments.

This is a terminal report but it should not be a final report. Due to unfavorable burning weather, it was impossible to finish the study within the projected time schedule. And because this time schedule could not be followed, the crew which had been assembled and trained for collecting basic data in this study, the Foote Canyon fire study, and the Buckskin fire study, can not be utilized. A new field effort will be needed, specifically to collect the additional after-treatment data on this study.

The study has produced good data and some good results. Value wise the data probably represents an exceptional return for the investment involved.

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